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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/725,381	12/03/2003	Han-Choon Lee	040044-0306859	3140

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EXAMINER

DOTY, HEATHER ANNE

ART UNIT PAPER NUMBER

2813

DATE MAILED: 08/23/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 10/725,381	Applicant(s) LEE, HAN-CHOON	
	Examiner Heather A. Doty	Art Unit 2813	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
 - If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
 - If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
 - Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 12 July 2005.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1,4,5,8,9 and 12-15 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1,4,5,8,9 and 12-15 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 03 December 2003 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date <u>12/3/03</u> | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Election/Restrictions

Applicant's election without traverse of Species II in the reply filed on 7/12/2005 is acknowledged.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 1, 4, 5, 8, 9, and 12-15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Applicant's Admitted Prior Art (APA) in view of Min et al. (Applied Physics Letters Vol. 75, Number 11, 1999) and Chen et al. (U.S. 6,596,643).

Regarding claims 1 and 13-15, APA teaches a method for forming a barrier metal of a semiconductor device, comprising forming an insulating layer on a semiconductor substrate and forming a contact hole opening in the insulating layer (instant specification pg. 2, line 15 – pg. 3, line 2). APA does not teach forming a TiSiN layer having a desired thickness by repeatedly performing a process of forming a TiSiN layer having an atomic layer thickness, which performs deposition of a Si layer inside the opening and on the insulating layer using an atomic layer deposition process and performs deposition of a certain precursor layer on the Si layer; and performing plasma processing for the TiSiN layer so as to remove impurities contained in the TiSiN layer.

Art Unit: 2813

Min et al. teaches a method for forming a barrier metal of a semiconductor device, comprising forming a TiSiN layer having a desired thickness by repeatedly performing a process of forming a TiSiN layer having an atomic layer thickness (pg. 1521, paragraph 2), which performs deposition of a Si layer inside the opening and on the insulating layer using an atomic layer deposition process and performs deposition of a certain precursor layer on the Si layer (pg. 1521, paragraphs 2-4; Min et al. teaches a cyclical MOALD technique of sequentially supplying TDMAT, SiH₄, and NH₃ to provide sequential Ti-Si-N layers. By the second cycle, TDMAT is deposited on top of the first Si layer, which is on top of the substrate, as required by instant claim 1). Min et al. does not teach plasma processing the TiSiN layer to remove impurities.

Chen et al. teaches a method of using TDMAT and SiH₄ to form a Ti-Si-N layer comprising plasma processing (N₂/H₂ plasma) the layer to remove CH₃ impurities from the film (column 7, lines 13-41; column 8, lines 41-43).

Therefore, at the time of the invention, it would have been obvious to combine the teachings of APA and Min et al. to form an insulating layer on a semiconductor substrate and form an opening in the insulating layer, as taught by APA, and then use the MOALD technique taught by Min et al. to deposit a TiSiN layer having a desired thickness. The motivation for doing so at the time of the invention would have been because MOALD techniques achieve near-perfect step coverage and can control precisely the thickness and composition of grown films, which is important when providing copper barrier diffusion materials to small-scale semiconductor devices, as expressly taught by Min et al. (pg. 1521, paragraphs 1 and 2).

It would further be obvious to combine the teachings of Chen et al. with the combined teachings of APA and Min et al. to plasma-process, using a plasma processed under an atmosphere of a nitrogen gas and a hydrogen gas, the Ti-Si-N layer to remove CH-based impurities. The motivation for doing so at the time of the invention would be because during the thermal decomposition of TDMAT (in the same temperature range taught in the instant specification, see Chen et al. column 8, lines 14-23 and instant claims 9 and 12), not all of the CH₃ groups are eliminated, and nitrogen plasma-processing the film causes nitrogen to replace NCH₃ groups in the film, as expressly taught by Chen et al. (column 7, lines 13-23).

Regarding claims 4, 5, and 8, Min et al. teaches that the Si layer is deposited using an SiH₄ gas and that the precursor layer is formed by TDMAT (pg. 1251, paragraph 2).

Regarding claims 9 and 12, the combined teachings of APA and Min et al. do not teach that the TiSiN layer having the atomic layer thickness is formed by reacting the precursor layer by thermal decomposition at a temperature ranging from 350 to 450°C.

However, Chen et al. teaches reacting a TDMAT precursor layer by thermal decomposition at a temperature of 360°C (column 8, lines 14-23) to achieve desirable step coverage (column 8, lines 25-26).

Therefore, at the time of the invention, it would have been obvious to one of ordinary skill in the art to combine the teachings of Chen et al. to the combined teachings of APA and Min et al. to form a TiSiN layer having an atomic layer thickness by reacting a precursor TDMAT layer by thermal decomposition at a temperature of

360°C. The motivation for doing so at the time of the invention would have been to achieve desirable step coverage, as taught by Chen et al.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Heather A. Doty, whose telephone number is 571-272-8429. The examiner can normally be reached on M-F, 8:30 - 5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead, Jr., can be reached at 571-272-1702. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

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